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# **Field survey on the incidence and severity of motion sickness in the Canadian Forces enclosed light armoured vehicle**

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**Defence R&D Canada**  
Technical Memorandum  
DRDC Toronto TM 2007-063  
April 2007

**Canada**



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## **Defence R&D Canada – Toronto**

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## Abstract

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In the Advanced Vehicle Architecture for a Net-Enabled Combat Environment Technology Demonstrator Project (ADVANCE TDP), there is a need to define the requirements of the active suspension system and how the resulting motion affects performance and well-being (i.e. incidence and severity of motion sickness). At the request of the Director Armoured Vehicles Program Management (DAVPM), a study to investigate the effects of motion disturbance in the LAV III (light armoured vehicle) was completed. During a two-week mechanized platoon commander course held at Canadian Forces Base (CFB) Gagetown, an anonymous questionnaire concerning the rating of 1) motion sickness symptoms and 2) mood and alertness was distributed daily to all of the course participants. Although the participants were encouraged to complete the questionnaire several times each day, compliance with instructions was adversely affected by the operational and physical demands of the course. In addition, uncontrolled variables such as noise, vibration, adverse weather, stress and fatigue likely affected the scores of diagnostic motion sickness symptoms and mood. The most frequently reported motion sickness symptoms were drowsiness, feeling warm and headaches. The most frequently reported mood parameters were weariness, sleepiness, and physical discomfort. Anecdotal reports suggested that the course participants, who were experienced infantry members, had habituated to the motion of the LAV III and were thus less susceptible to motion disturbance than less experienced members.

## Résumé

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Dans le cadre du projet d'architecture de véhicule avancée pour environnement de combat réseautique (ADVANCE TDP), il est nécessaire de définir les besoins de la suspension adaptative et la façon dont les mouvements qui en résultent influent sur le rendement et le bien-être (c.-à-d., l'incidence et la gravité du mal des transports). À la demande du Directeur – Gestion de projet de véhicule blindé (D Gest PVM), une étude ayant pour objet d'étudier les effets du mal des transports à bord du VBL III (véhicule blindé léger) a été menée. Lors d'un cours de commandement de peloton mécanisé de deux semaines tenu à la Base des Forces canadiennes (BFC) Gagetown, un questionnaire anonyme où l'on demandait aux participants au cours d'évaluer 1) leurs symptômes du mal des transports et 2) leur humeur et leur vivacité d'esprit a été distribué quotidiennement. Bien que l'on encourageait les participants à remplir le questionnaire plusieurs fois par jour, les exigences opérationnelles et physiques du cours nuisaient à leur capacité de se conformer aux instructions. De plus, des variables non contrôlées telles que le bruit, les vibrations, le mauvais temps, le stress et la fatigue ont probablement eu une incidence sur l'évaluation des symptômes du mal des transports et de l'humeur. Les symptômes du mal des transports les plus souvent signalés furent la somnolence, la sensation de chaleur et les maux de tête. Les paramètres d'humeur les plus souvent signalés furent la lassitude, la somnolence et l'inconfort physique. Des rapports isolés laissent entendre que les participants au cours qui étaient des fantassins chevronnés étaient habitués au mouvement du VBL III et étaient donc moins susceptibles d'être perturbés que les soldats d'infanterie moins chevronnés.

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## Executive summary

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### **Field survey on the incidence and severity of motion sickness in the Canadian Forces enclosed light armoured vehicle:**

**Bob Cheung; Ann Nakashima; Kevin Hofer; 2Lt Brian Coyle; DRDC Toronto TM 2007-063; Defence R&D Canada – Toronto; April 2007.**

**Background:** In the Advanced Vehicle Architecture for a Net-Enabled Combat Environment Technology Demonstrator Project (ADVANCE TDP), there is a need to define the requirements of the active suspension system in terms of vibration and absorbed power. In particular, the response of the suspension system to different types of terrain may affect the performance and well-being of the vehicle occupants (e.g. the incidence and severity of motion sickness). At the request of the Director Armoured Vehicles Program Management (DAVPM), a study to investigate the effects of motion disturbance in the LAV III (light armoured vehicle) was completed. During a two-week mechanized platoon commander course held at Canadian Forces Base (CFB) Gagetown, an anonymous questionnaire concerning the rating of 1) motion sickness symptoms and 2) mood and alertness was distributed daily to all of the course participants.

**Results:** The rapid pace of the exercises, high performance expectations and physical demands of the course (i.e. constant work, sleep deprivation) affect compliance with participation in the survey. The response rate thus varied depending on the particular demands of the course on a given day. Environmental and operational factors such as noise, vibration, adverse weather conditions, fatigue and stress likely had an affect on the diagnostic motion sickness symptom scores and the mood scores. The most commonly reported motion sickness symptoms were drowsiness, feeling of warmth and headaches. The most commonly reported mood parameters were weariness, sleepiness and physical discomfort.

**Significance:** The questionnaire results suggested that severe motion sickness (to the point of nausea or emesis) was a relatively uncommon experience for the course participants. However, motion disturbance may be a factor for personnel who are less familiar with the motion of the LAV III (i.e. younger infantry members).

**Future plans:** To gain a quantitative understanding of the effects of motion on performance, correlations between individual physiological responses, specific motion sickness symptoms and vehicular motion must be obtained. Because it is very difficult to obtain such measurements in the field, it is recommended that such measurements be performed in a controlled laboratory environment.

## Sommaire

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### **Field survey on the incidence and severity of motion sickness in the Canadian Forces enclosed light armoured vehicle:**

**Bob Cheung; Ann Nakashima; Kevin Hofer; 2Lt Brian Coyle; DRDC Toronto TM 2007-063; R & D pour la défense Canada – Toronto; Avril 2007.**

**Contexte :** Dans le cadre du projet d'architecture de véhicule avancée pour environnement de combat réseau-centrique (ADVANCE TDP), il est nécessaire de définir les besoins de la suspension adaptative en ce qui concerne les vibrations et la puissance absorbée. Plus particulièrement, la réponse du système de suspension à différents types de terrains pourrait avoir une incidence sur le rendement et le bien-être des occupants du véhicule (c.-à-d., l'incidence et la gravité du mal des transports). À la demande du Directeur – Gestion de projet de véhicule blindé (D Gest PVM), une étude ayant pour objet d'étudier les effets du mal des transports à bord du VBL III (véhicule blindé léger) a été menée. Lors d'un cours de commandement de peloton mécanisé de deux semaines tenu à la Base des Forces canadiennes (BFC) Gagetown, un questionnaire anonyme où l'on demandait aux participants au cours d'évaluer 1) leurs symptômes du mal des transports et 2) leur humeur et leur vivacité d'esprit a été distribué quotidiennement.

**Résultats :** Le rythme rapide des exercices, le haut niveau de rendement attendu et les exigences physiques du cours (c.-à-d., travail constant, privation de sommeil) gênaient parfois la participation à l'enquête. Le taux de réponse variait donc en fonction des exigences particulières de la journée. Des facteurs environnementaux et opérationnels tels que le bruit, les vibrations, le mauvais temps, la fatigue et le stress ont probablement eu une incidence sur l'évaluation des symptômes du mal des transports et de l'humeur. Les symptômes du mal des transports les plus souvent signalés furent la somnolence, la sensation de chaleur et les maux de tête. Les paramètres d'humeur les plus souvent signalés furent la lassitude, la somnolence et l'inconfort physique.

**Importance :** Les résultats de l'enquête laissent entendre que le mal des transports grave (au point de souffrir de nausées ou de vomissements) était une expérience relativement peu répandue chez les participants au cours. Cependant, le mal des transports pourrait être un facteur chez les militaires qui sont moins habitués aux mouvements du VLB III (c.-à-d., les jeunes fantassins).

**Plans futurs :** Pour quantifier les effets du mouvement sur le rendement, il faut établir des corrélations entre les différentes réponses physiologiques, les symptômes précis du mal des transports et les mouvements de véhicules. Comme il est très difficile d'obtenir de telles mesures sur le terrain, il est recommandé qu'elles soient obtenues dans un environnement contrôlé, soit en laboratoire.



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# **1 Background**

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Many different forms of land transport, from cars and coaches to military vehicles, cause motion discomfort with symptoms ranging from nausea to vomiting and/or retching. There are also documented changes in behaviour and performance such as: loss of well-being; decreased spontaneity; decreased readiness to perform and decreased muscular and eye-hand coordination. Enclosed cross-country vehicles, such as tanks, command and control vehicles (C2V), light armoured vehicle (LAV) personnel carriers and future Multi-Mission Effects Vehicles (MMEV) can be highly nauseogenic although no figures on the incidence and severity of motion disturbance in the Canadian Forces (CF) are available. A study on United States Army personnel using C2V vehicles indicated that one out of eight subjects experienced two episodes of vomiting, seven of the eight subjects reported other motion sickness symptoms (Cowings et al. 2001). The most frequently reported symptom was drowsiness which was reported a total of 19 times in a sample of 24 subjects. There was also an overall decrease in performance during the C2V exercise. Another study showed that 74% of Marines tested reported moderate to severe motion sickness symptoms after working at a computer workstation in a moving assault vehicle (Rickert 2000). Studies such as these, as well as anecdotal information received from the field in the Canadian Forces suggest that soldier performance may be affected by motion and this issue should be examined and resolved to an acceptable level. The specific purpose of this study is to conduct a field survey into the nature and severity of motion discomfort, current mood and alertness in passengers travelling in the LAV III in transit to mission training. Specifically, we are interested in the development of motion sickness of the participants during their transit to and during the training site and to monitor their effects over a nine-day training period.

## **2 Experimental Protocol**

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### **2.1 Subjects**

Two platoons of active duty soldiers (males between the ages of 18 to 60, approximately 60 in total) from CFB Gagetown participated in this survey in November 2006. Subjects were fully briefed as to the purpose of this voluntary survey by the principal investigator. Subjects were asked to sign an informed consent indicating that they had been briefed to their satisfaction and had been given the chance to ask the principal investigator questions.

### **2.2 Description of the course**

The experiment was conducted during a nine-day platoon commander course held 6-17 November 2007. The weather conditions were mostly rainy except for snow on the first day. Temperatures ranged from 0-12°C. The ground was very muddy throughout the two-week period. Each platoon consisted of 3 LAVs plus a supervising LAV of directing staff (DS). At the beginning of each week the participants travelled from the garrison to the training area along hard-packed, but unpaved, mud roads scattered with pot holes at 40-80 km/h; the journey took approximately 45 minutes. The conditions of the return journey back to the garrison area at the

end of the week were similar, with the notable difference being that the return trips generally occurred soon after some form of off-road exercise.

For this course, the majority of the time was spent on hasty attacks (6-14 Nov). During a hasty attack, sudden contact with the enemy forces the platoon to rapidly form a plan and immediately attack. The platoon commander LAV would leave to perform the reconnaissance (mostly on hard-packed roads), then return lead the remainder of the platoon to the attack. The attacks generally occurred off-road; thus, the vehicle speed varied depending on the terrain. Once the enemy was reached, the final assault was performed on foot. This stage of the attack typically lasted about 10 minutes, followed by a de-briefing. At the beginning of the course, the hasty attacks lasted approximately two hours; the time decreased to about an hour as the platoons gained experience.

No exercises were performed on 11-13 November. Delay operations, area defence and demolition guard tasks were performed on 15-16 Nov, during which there was little vehicle movement. On the evening of 16 Nov and morning of 17 Nov, a deliberate attack was performed. A deliberate attack allows more time for detailed planning, build-up of forces, reconnaissance and rehearsal. There is vehicle movement, but it occurs over a much longer time period than in a hasty attack. While the vehicles were idle during these attacks, the soldiers stayed in the vehicles, as would generally be expected on the battlefield. Whenever possible, the soldiers were prompted to fill out their questionnaires following the attacks.

## **2.3 Methodology**

During the nine-day platoon commander course, anonymous questionnaires were distributed to the participants on each day. The survey questionnaire was composed of motion sickness symptoms rating (diagnostic scores) and a mood and alertness rating (mood scores). Each participant was asked to rate their motion sickness symptoms based on Graybiel's diagnostic criteria for motion sickness (Graybiel et. al. 1968) and current mood and alertness (DeRoshia and Greenleaf 1993) as illustrated in Appendix A. The questionnaires took approximately 60 seconds to complete. Participants were requested to fill out the questionnaire at the start of the day before entering the LAV as a baseline condition, during travel to and from the training area, between specific areas within the training area while the vehicle was in motion; and whenever there was a change in their subjective symptoms thereafter. Although the task of filling out the questionnaire may have aggravated sickness symptoms, this task simulates the operational environment in which soldiers are required to read and comprehend orders, instruments, topographical maps, etc. The questionnaire booklets were collected at the end of the day (at the disposal point [DP]) when possible.

## **2.4 Data Analysis**

The survey study was conducted under the agreement that we could not interfere with the training exercise. As a result, the survey could not be made under controlled conditions commonly available in the laboratory setting. Unfortunately, not all subjects were able to participate and return their questionnaires every day or as often as was desirable. Because of the large number of missing data on a specific day within and across subjects, the data collected can be analyzed using

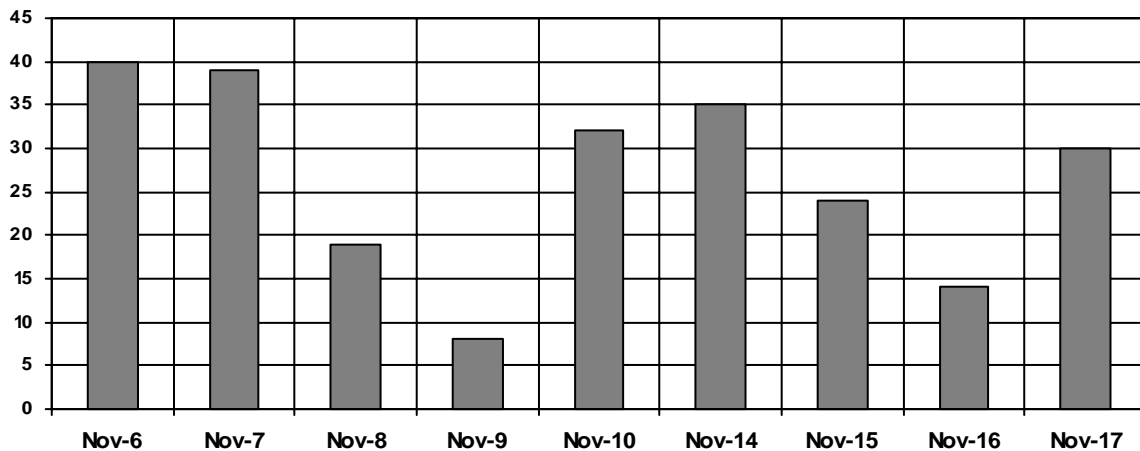
descriptive statistics only. Details of the collected data are tabulated in the appendix. Summary of results are presented in the following section.

## 3 Results

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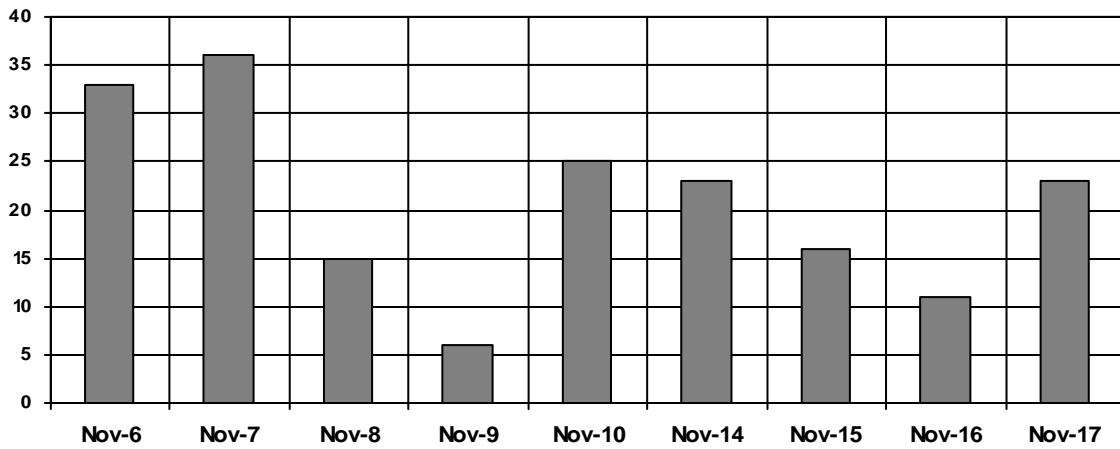
### 3.1 Group data analysis

- The number of subjects that returned their informed consent did not match the number of subjects that participated on a specific day, e.g., the maximum number of subjects that participated on a single day was 40. The total number of consent form returned was 43 and there were 55 different subjects. Apparently, 12 subjects failed to return their consent forms. Some of these subjects may have been DS who joined the course in progress.
- Not all subjects participated in the questionnaire survey for all 9 days and no single subject participated on all 9 days.
- The total number of subjects that participated on each day of the 9-day exercise range from 8 to 40 depending on the specific day, the mean number of subject is 26, details are shown in Figure 1.



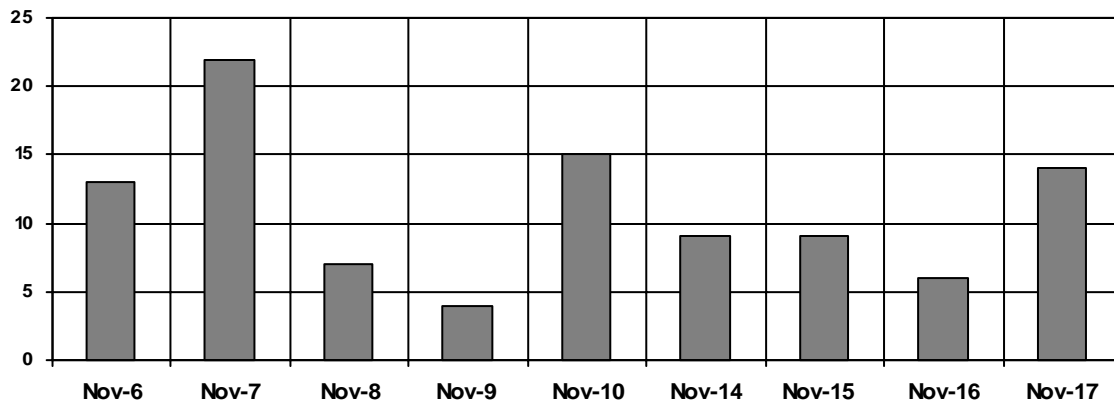
*Figure 1: Number of subjects who returned at least one questionnaire, by day.*

- The total number of subjects who reported mild symptoms of motion sickness on each day and their distribution over the survey period are shown in Figure 2.



*Figure 2: Number of subjects reporting mild motion sickness symptoms, by day.*

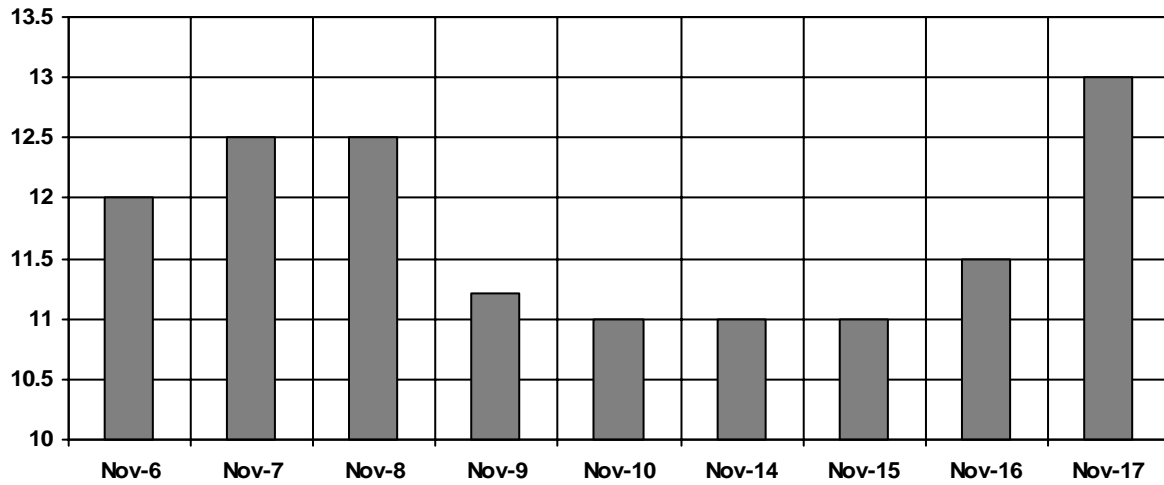
- The total number of subjects who reported moderate/severe symptoms of motion sickness on each day and their distribution over the survey period are shown in Figure 3.



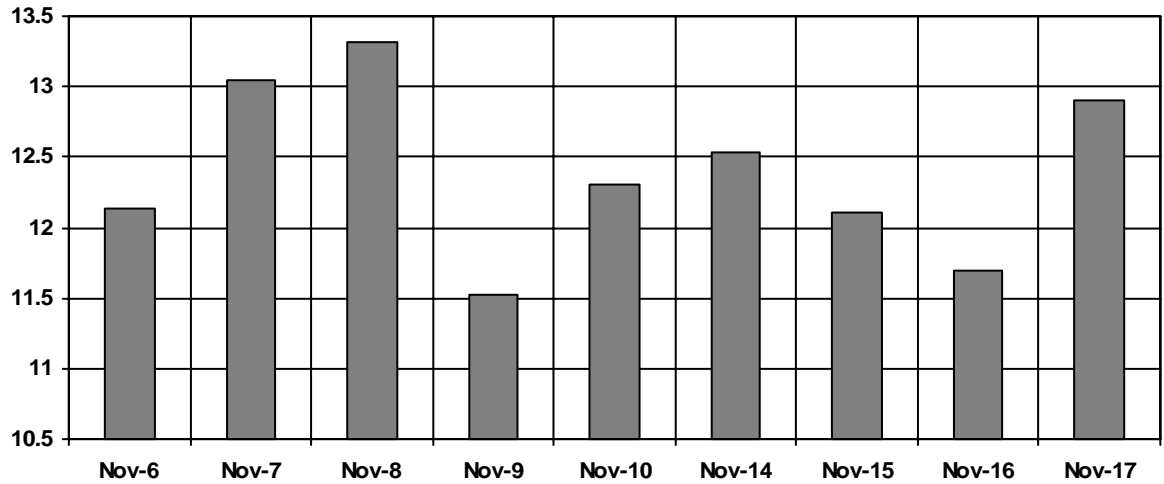
*Figure 3: Number of subjects reporting moderate/severe motion sickness symptoms, by day*



- The maximum diagnostic score for symptoms of motion sickness is 40. The median and mean diagnostic symptom score across the survey period are shown in Figures 4 and 5, respectively.



*Figure 4: Median motion sickness symptom score (out of 40), by day.*



*Figure 5: Mean motion sickness symptom score (out of 40), by day.*

- The number of subjects who reported warmth/flushing, dizziness, headache, drowsiness, salivation, paleness, sweating, stomach awareness, stomach discomfort and nausea across the survey period are shown in Figure 6 (number of respondents given in parentheses).

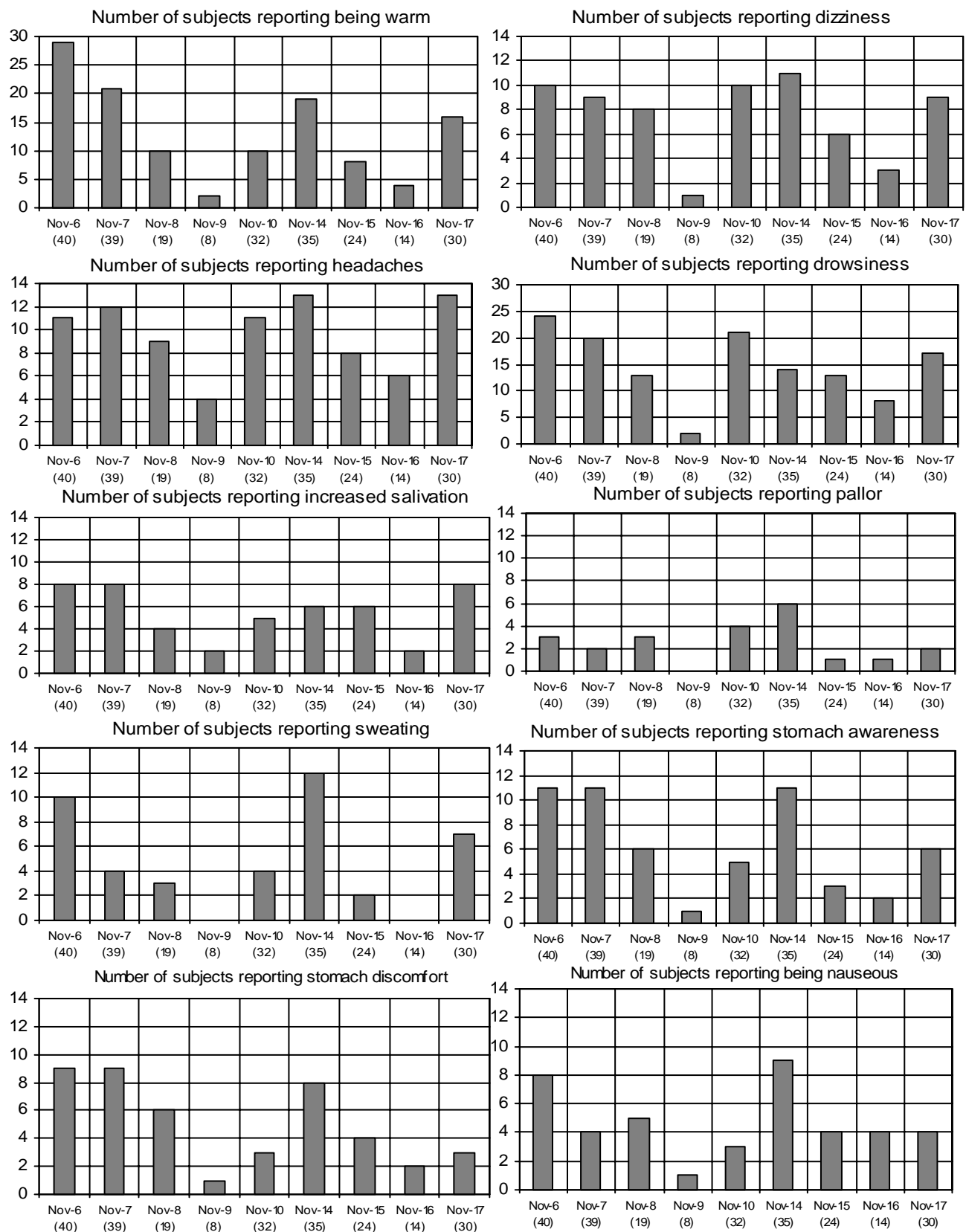
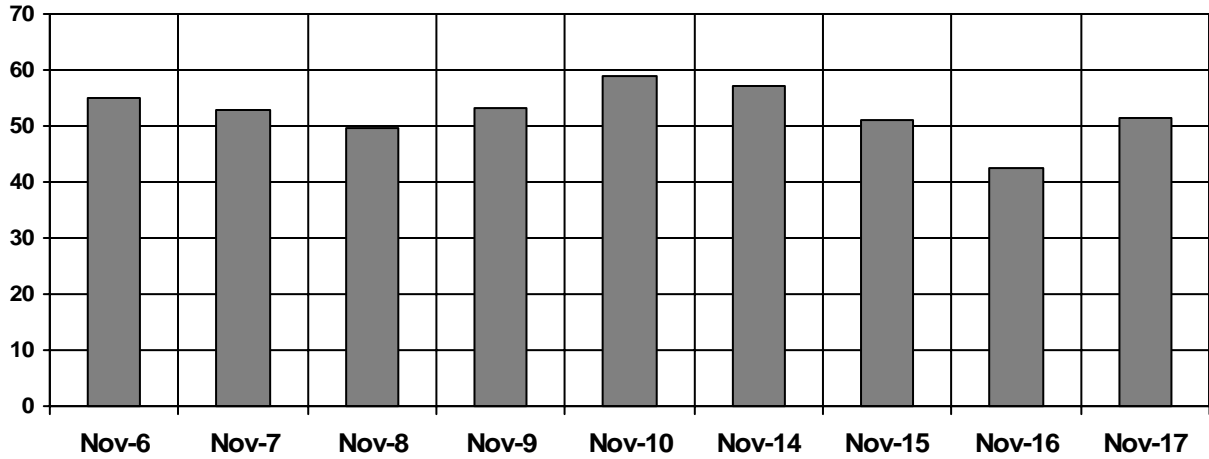
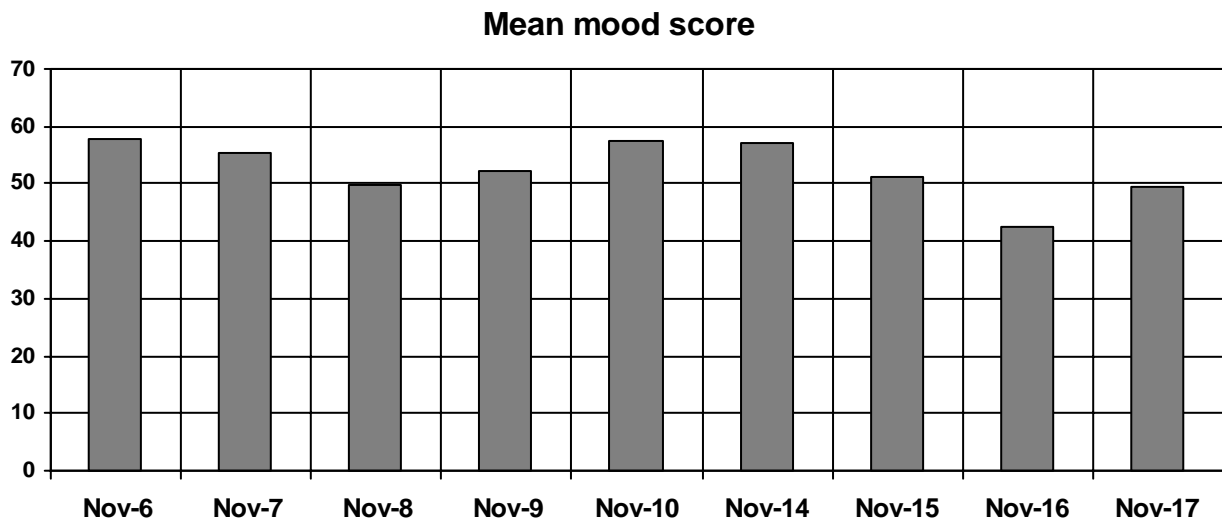


Figure 6: Number of subjects reporting specific motion sickness symptoms, by day.

- The maximum diagnostic score for the mood parameter is 90. The median and mean diagnostic mood score across the survey period are shown in Figures 7 and 8, respectively.



*Figure 7: Median mood scores (out of 90), by day.*



*Figure 8: Mean mood scores (out of 90), by day.*

The number of subjects who reported boredom, sleepiness, weariness, loss of concentration, tenseness, sadness, high discomfort, unpleasant and troubling falling asleep across the survey period are shown in Figure 9 (number of respondents given in parentheses).

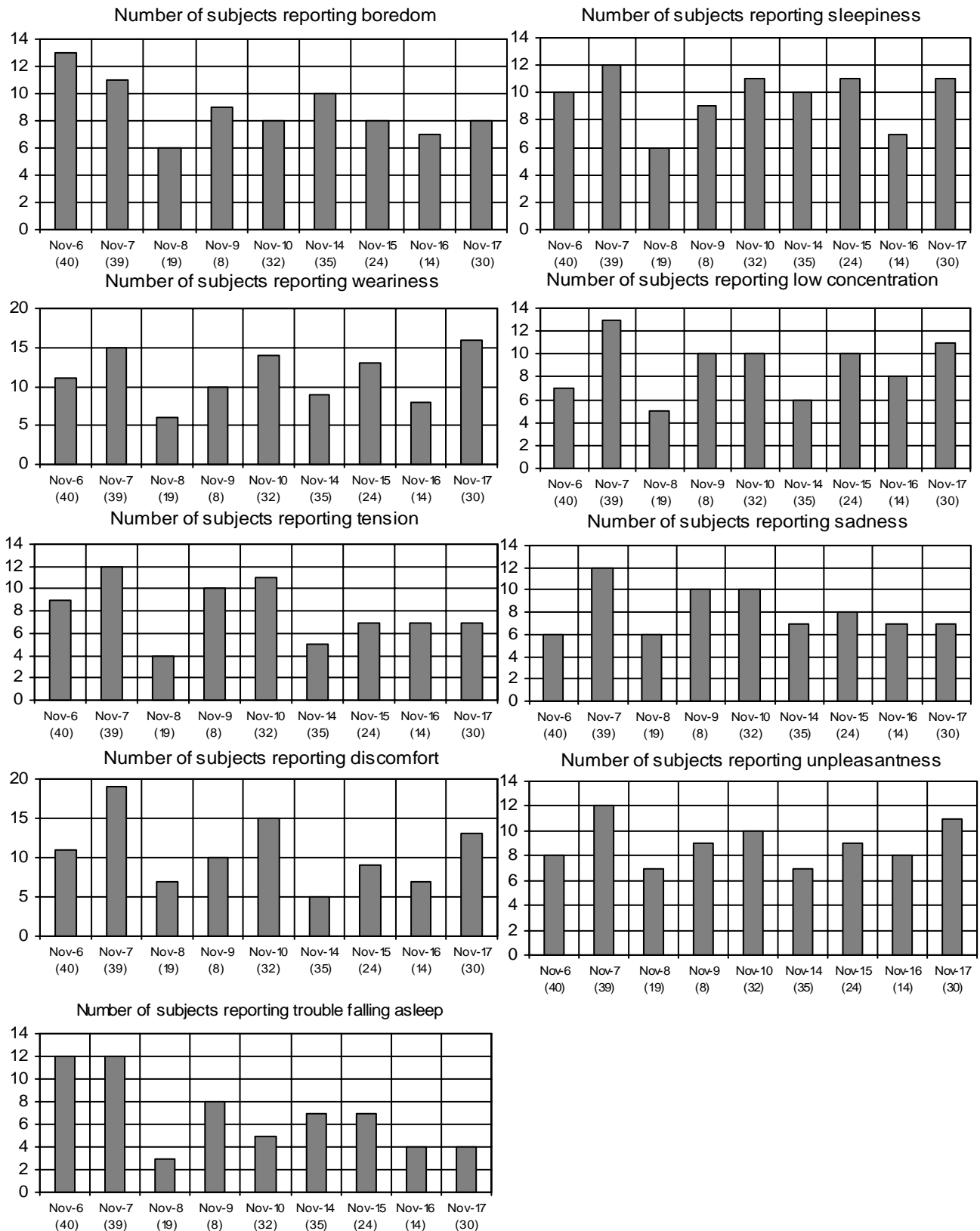


Figure 9: Number of subjects reporting specific mood symptoms, by day.

## 3.2 Individual subject analysis

- Specific diagnostic symptoms ranked by the percentage of subjects reporting them across days are listed in Table 1 in Appendix B.
- There were seven reported incidences of vomiting that are not represented in Table 1: one subject who vomited four times on Nov 8, and two subjects who vomited on Nov 14 (one subject vomited once, the other, twice).
- Specific mood parameters ranked by the percentage of subjects reporting them across days are listed in Table 2 in Appendix B.
- Mean and median diagnostic scores based on cumulative total across days for each subject are tabulated in Table 3 in Appendix B.
- Mean and median mood parameter scores based on cumulative total across days for each subject are tabulated in Table 4 in Appendix B.
- Mean and median combined diagnostic and mood parameter scores based on cumulative total across days for each subject are tabulated in Table 5 in Appendix B.

## 4 Discussion

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There are a number of problems associated with conducting field studies. The lack of experimental control is perhaps the most important. In addition, the experimenter must be able to isolate the participants from effects that are not of interest to the study but might influence the measured parameters. In a field study it is extremely difficult to eliminate any unwanted variables. Potential confounding variables are noise, vibration and heat. Noise levels generally increase with increasing vehicle speed, while mechanical vibrations tend to increase in magnitude with the roughness of terrain. These stressors are known to cause physical and mental discomfort. In addition, large variations in temperature were experienced by the subjects throughout the period of data collection. Several participants complained about the temperature control in the back of the LAV; some complained that it was too hot while others commented that it was too cold. These uncontrolled environmental factors would increase the variability of the parameters that were measured (symptoms of motion sickness and mood) beyond that produced by motion sickness alone, and the difference between the means of the dependent variables would be artificially increased.

Compliance with the survey, in terms of the frequency with which the survey was completed, was made difficult by the continuous 24 hour nature of the training exercises. The physical and mental demands of the course, combined with environmental factors and the fact that the participants were being evaluated on their performance, led to high stress levels and likely contributed to the decrease in participation in the survey as the course went on. Nevertheless, our field study in the LAV indicated that varying symptoms of motion sickness and mood changes were reported by the participants. However, the non-motion sickness stressors associated with the course may have contributed to the extreme hunger, tiredness, general malaise, drowsiness, mood, and body temperature that were reported. It was reported that throughout the training

course, the soldiers had an average of 2-3 hours of sleep in addition to a brief rest period during the day. It was the intent of the DS to create a state of sleep deprivation in addition to the overall duress of the course.

Motion sickness is a relatively uncommon experience for most individuals and usually occurs in individuals riding in some form of transportation with which they are not familiar. Anecdotal information suggested that many of the soldiers might have initially experienced motion sickness in the past when they first began training for mechanized warfare; however, they eventually habituated to the unusual motion and became desensitized. Other observations suggested that, in Afghanistan, many individuals who succumbed to motion sickness in the LAVs were generally civilian contractors or other non-mechanized warfighters; this held true even on paved roads. In addition, nervousness and stress in the war zone may exacerbate any mild symptoms of motion discomfort. Since most of the participants were experienced soldiers with over 10 years in the mechanized division, their experience in the LAV might have influenced the results of the survey.

As mentioned above, due to the operational requirements, the responses from the participants were inconsistent, and the missing data made it difficult to perform time series analysis on an individual or the group's development of motion sickness symptoms and mood changes. Ideally, correlation between individual physiological responses and specific motion sickness symptoms and objective measurements of vehicular motion (acceleration and deceleration in multi-axes) would provide further information that can be used to compare with the next generation vehicle that might employ active suspension mechanism. It is recommended that such comparisons should be performed in a controlled laboratory condition (e.g. motion simulator) prior to field trials. The methodology (diagnostic symptom and mood scale) demonstrated in the present survey may be applied to future studies.



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## Annex A Questionnaire

*Table 1: Motion sickness symptoms and alertness questionnaire, adapted from Graybiel et al (1968) and DeRoshia and Greenleaf (1993).*

Date:		Time:				
When were you last in a LAV (circle one)?		< 1 Week	> 1 Month	>6 Months	Never	
CIRCLE YOUR CURRENT SEAT POSITION:		<input type="radio"/> C	1	2	3	4
		<input type="radio"/> GR	5	6	7	8
PLACE A CHECK BESIDE THE APPROPRIATE LEVEL		None	Mild	Moderate	Severe	
Do you feel warm?						
Do you feel dizzy?						
Do you have a headache?						
Are you drowsy?						
Are you salivating?						
Do you look pale (ask someone)?						
Are you sweating?						
Do you have stomach awareness?						
Do you have stomach discomfort?						
Are you nauseous?						
Have you vomited today?						
If yes, how many times?						
CIRCLE A NUMBER FROM 1 TO 10 TO IN THE FOLLOWING CATEGORIES:						
Motivation	Bored 1 2 3 4 5 6 7 8 9 10 Interested					
Arousal state	Sleepy 1 2 3 4 5 6 7 8 9 10 Alert					
Fatigue Level	Weary 1 2 3 4 5 6 7 8 9 10 Energetic					
Ease of concentration	Very Low 1 2 3 4 5 6 7 8 9 10 Very High					
Psychological Tension	Tense 1 2 3 4 5 6 7 8 9 10 Relaxed					
Elation	Sad 1 2 3 4 5 6 7 8 9 10 Happy					
Physical discomfort	Very high 1 2 3 4 5 6 7 8 9 10 Very low					
Contentedness	Unpleasant 1 2 3 4 5 6 7 8 9 10 Pleasant					
Trouble falling asleep	Much worse 1 2 3 4 5 6 7 8 9 10 Much better					
How many times did you wake up last night?						
When did you last consume alcohol and how many glasses did you consume?						

## Annex B Motion Sickness Data Tables

Table 2: Summary of diagnostic symptoms of motion sickness.

Date	Nov 6	Nov 7	Nov 8	Nov 9	Nov 10	Nov 14	Nov 15	Nov 16	Nov 17
No. of subjects	40	39	19	8	32	35	24	14	30
No. with mild symptoms	33	36	15	6	25	23	16	11	23
No. with moderate/severe symptoms	13	22	7	4	15	9	9	6	14
Diagnostic median score	12	12.5	12.5	11.21	11	11	11	11.5	13
Diagnostic mean Score	12.13	13.05	13.32	11.52	12.3	12.4	12.1	11.7	12.9
% warm (number of Ss)	72.5 (29)	53.8 (21)	52.6 (10)	25 (2)	31.3 (10)	54.3 (19)	33.3 (8)	28.6 (4)	53.3 (16)
% dizzy	25 (10)	23.1 (9)	42.1 (8)	12.5 (1)	31.3 (10)	31.4 (11)	25.0 (6)	21.4 (3)	30.0 (9)
% headache	27.5 (11)	30.8 (12)	47.4 (9)	50 (4)	34.4 (11)	37.1 (13)	33.3 (8)	42.9 (6)	43.3 (13)
% drowsy	60 (24)	51.3 (20)	68.4 (13)	25 (2)	65.6 (21)	40.0 (14)	54.2 (13)	57.1 (8)	56.7 (17)
% salivate	20 (8)	20.5 (8)	21.1 (4)	25 (2)	15.6 (5)	17.1 (6)	25.0 (6)	14.3 (2)	26.7 (8)
% pale	7.5 (3)	5.1 (2)	15.8 (3)	0	12.5 (4)	17.1 (6)	4.2 (1)	7.1 (1)	6.7 (2)
% sweating	2.5 (10)	10.3 (4)	15.8 (3)	0	12.5 (4)	34.3 (12)	8.3 (2)	0	23.3 (7)
% stomach awareness	27.5 (11)	23.8 (11)	31.6 (6)	12.5 (1)	15.6 (5)	31.4 (11)	12.5 (3)	14.3 (2)	20 (6)
% stomach discomfort	22.5 (9)	23.1 (9)	31.6 (6)	12.5 (1)	9.4 (3)	22.7 (8)	16.7 (4)	14.3 (2)	10 (3)
% nauseous	20 (8)	10.3 (4)	26.3 (5)	12.5 (1)	9.4 (3)	25.7 (9)	16.7 (4)	28.6 (4)	13.3 (4)

Maximum diagnostic score is 40.

Diagnostic mean value is based on the number of subjects in the respective column.

Percentages are based on responses that were 2 (mild) or higher.

A higher score translates into more robust symptoms of motion sickness.

Table 3: Summary of mood parameters.

Date	Nov 6	Nov 7	Nov 8	Nov 9	Nov 10	Nov 14	Nov 15	Nov 16	Nov 17
No. of subjects	40	39	18	8	32	34	24	14	30
Diagnostic median score	55	52.8	49.7	53.2	58.8	57	51	42.5	51.5
Diagnostic mean score	57.9	55.2	49.7	52.2	57.4	57.0	51.3	46.6	49.3
% bored (number of Ss)	32.5 (13)	27.5 (11)	15 (6)	22.5 (9)	25.0 (8)	29.4 (10)	33.3 (8)	50.0 (7)	26.7 (8)
% sleepy	25 (10)	30 (12)	15 (6)	22.5 (9)	34.4 (11)	29.4 (10)	45.8 (11)	50.0 (7)	36.7 (11)
% weary	27.5 (11)	37.5 (15)	15 (6)	25 (10)	43.8 (14)	26.5 (9)	54.2 (13)	57.1 (8)	53.3 (16)
% low concentration	17.5 (7)	32.5 (13)	12.5 (5)	25 (10)	31.3 (10)	17.7 (6)	41.7 (10)	57.1 (8)	36.7 (11)
% tense	22.5 (9)	30 (12)	10 (4)	25 (10)	34.4 (11)	14.7 (5)	29.2 (7)	50.0 (7)	23.3 (7)
% sad	15 (6)	30 (12)	15 (6)	25 (10)	31.3 (10)	20.6 (7)	33.3 (8)	50.0 (7)	23.3 (7)
% high discomfort	27.5 (11)	47.5 (19)	17.5 (7)	25 (10)	46.9 (15)	14.7 (5)	37.5 (9)	50.0 (7)	43.3 (13)
% unpleasant	20 (8)	30 (12)	17.5 (7)	22.5 (9)	31.3 (10)	20.6 (7)	37.5 (9)	57.1 (8)	36.7 (11)
% trouble falling asleep	30 (12)	30 (12)	7.5 (3)	20 (8)	15.6 (5)	20.6 (7)	29.2 (7)	28.6 (4)	13.3 (4)

Maximum diagnostic score is **90**.

Diagnostic mean value is based on the number of subjects in the respective column.

Percentages are based on responses of 4 (1-10 likert-type scale) or lower.

Higher percentage = more negative mood score

Table 4: Summary of diagnostic motion sickness symptoms by subject (continued on next page).

Subject	Nov-06	Nov-07	Nov-08	Nov-09	Nov-10	Nov-14	Nov-15	Nov-16	Nov-17	Total Score	Mean score based on participation	Median score based on participation	Maximum possible score based on participation	% of maximum score based on participation	% of maximum score
89				11.3						11.3	11.3	11.3	40	28.1	3.1
90		17.7								17.7	17.7	17.7	40	44.2	4.9
176	12.3	17.3				16.3	11.3	10.0	9.0	76.2	12.7	11.8	240	31.8	3.5
235	11.8	12.0			13.0				17.0	53.8	13.4	12.5	160	33.6	3.7
650	15.0	17.6			10.0	14.4			18.0	75.0	15.0	15.0	200	37.5	4.2
714	6.7	10.0			10.0	10.0				36.7	9.2	10.0	160	22.9	2.5
742	10.5	12.0			13.0	11.3				46.8	11.7	11.7	160	29.3	3.3
1001	10.5	10.5				11.0	15.0			47.0	11.8	10.8	160	29.4	3.3
1002	12.0	10.8	12.7		12.0	10.0		13.0		70.4	11.7	12.0	240	29.3	3.3
1003	12.0	13.0							11.5	36.5	12.2	12.0	120	30.4	3.4
1305						10.0				10.0	10.0	10.0	40	25.0	2.8
1398	6.7	11.0			10.0	10.0	10.0	10.0		57.7	9.6	10.0	240	24.0	2.7
1712	12.0	11.8				11.0			11.0	45.8	11.4	11.4	160	28.6	3.2
1742			12.3							12.3	12.3	12.3	40	30.8	3.4
1992	14.5	11.5		12.7					11.0	49.7	12.4	12.1	160	31.0	3.4
2089	15.3	13.3	12.7		10.0	11.2	11.7	8.3	16.0	98.5	12.3	12.2	320	30.8	3.4
2342					11.0					11.0	11.0	11.0	40	27.5	3.1
2405	11.0	17.7				17.0			16.0	61.7	15.4	16.5	160	38.5	4.3
2463	12.5	10.4	10.0			11.0	11.3	12.0	10.0	77.2	11.0	11.0	280	27.6	3.1
2667							10.0	11.0		21.0	10.5	10.5	80	26.3	2.9
2744		16.7								16.7	16.7	16.7	40	41.7	4.6
3389	10.0					10.0				20.0	10.0	10.0	80	25.0	2.8
3684	11.5	13.6			10.0		11.0	11.0	10.5	67.6	11.3	11.0	240	28.2	3.1
3761	22.0	14.0				21.0	17.0		14.5	88.5	17.7	17.0	200	44.3	4.9
3931	11.0	13.0	11.2	11.6	13.0	10.3			11.5	81.6	11.7	11.5	280	29.2	3.2
4111	13.0	12.8	11.0			14.3	17.3	15.0	15.7	99.0	14.1	14.3	280	35.4	3.9
4169	11.6		12.3			10.0	10.0	12.5		56.4	11.3	11.6	200	28.2	3.1
4310			12.5							12.5	12.5	12.5	40	31.3	3.5

Subject	Nov-06	Nov-07	Nov-08	Nov-09	Nov-10	Nov-14	Nov-15	Nov-16	Nov-17	Total Score	Mean score based on participation	Median score based on participation	Maximum possible score based on participation	% of maximum score based on participation	% of maximum score
4318	13.2	14.3		14.5		14.7	14.5	12.8	14.0	98.0	14.0	14.3	280	35.0	3.9
4478	12.0	14.0	15.5				11.0	13.0	15.0	80.5	13.4	13.5	240	33.5	3.7
4670	13.7	11.8			10.0	18.5	14.0			68.0	13.6	13.7	200	34.0	3.8
4790		20.0								20.0	20.0	20.0	40	50.0	5.6
4839					13.0				15.0	28.0	14.0	14.0	80	35.0	3.9
4860	12.5	13.8	14.0		19.0	15.3			12.5	87.2	14.5	13.9	240	36.3	4.0
4860	10.0	15.7			13.0	10.0	13.3			62.0	12.4	13.0	200	31.0	3.4
4970	12.3		13.0		12.0	10.0				47.3	11.8	12.2	160	29.6	3.3
5109					10.0		10.0			20.0	10.0	10.0	80	25.0	2.8
5366	10.0	10.0	10.0			10.0	10.0		10.0	60.0	10.0	10.0	240	25.0	2.8
6256			12.5							12.5	12.5	12.5	40	31.3	3.5
6592	16.0				16.0	14.0			16.0	62.0	15.5	16.0	160	38.8	4.3
6744	10.7	11.2	10.5	11.2	11.0	17.3			13.5	85.4	12.2	11.2	280	30.5	3.4
6776					14.0		14.0			28.0	14.0	14.0	80	35.0	3.9
7344	12.0					11.7			13.5	37.2	12.4	12.0	120	31.0	3.4
8187		13.3								13.3	13.3	13.3	40	33.1	3.7
8256	11.0	11.0				12.5	11.8		10.0	56.3	11.3	11.0	200	28.2	3.1
8550	12.0	10.3			12.0		10.0		10.0	54.3	10.9	10.3	200	27.1	3.0
8731		12.5				17.0	15.5	16.0	15.0	76.0	15.2	15.5	200	38.0	4.2
8774	11.6	10.3	13.0		10.0	10.0				54.9	11.0	10.3	200	27.5	3.1
8787	10.0		10.0		10.0	10.0			13.5	53.5	10.7	10.0	200	26.8	3.0
8831	12.3	10.8		11.0		10.8	11.3		11.0	67.2	11.2	11.0	240	28.0	3.1
8872	10.5	10.0		10.0	10.0	10.0			10.0	60.5	10.1	10.0	240	25.2	2.8
9477	13.0	11.6	13.6		13.0				12.0	63.2	12.6	13.0	200	31.6	3.5
9592	10.5	13.2				11.6	10.7	10.0	10.0	65.9	11.0	10.6	240	27.5	3.1
9838	12.0	12.3	19.3	10.0		10.8	10.0	8.8		83.1	11.9	10.8	280	29.7	3.3
9902	18.0	16.5	27.0		14.0	12.0	10.0		14.5	112.0	16.0	14.5	280	40.0	4.4
mean	12.1	13.0	13.3	11.5	12.0	12.4	12.1	11.7	12.9	53.0	12.6	12.5	170.2	31.5	3.5
median	12.0	12.5	12.5	11.2	12.0	11.0	11.3	11.5	13.0	56.3	12.2	12.0	200.0	30.5	3.4

Maximum diagnostic score per day is **40**, and for the nine days of the study is **360** (% of maximum score shown).

Table 5: Summary of mood parameters by subject (continued on next page).

Subject	Nov-06	Nov-07	Nov-08	Nov-09	Nov-10	Nov-14	Nov-15	Nov-16	Nov-17	Total Score	Mean score based on participation	Median score based on participation	Maximum possible score based on participation	% of maximum score based on participation	% of maximum score
89				38.3						38.3	38.3	38.3	90	42.5	4.7
90	34.3									34.3	34.3	34.3	90	38.1	4.2
176	51.3	39.3			41.5	40.3	51.7	64.0	52.0	340.1	48.6	51.3	630	54.0	6.0
235	62.3	50.0			46.8				34.5	193.6	48.4	48.4	360	53.8	6.0
650	42.8	67.0			34.5	67.6			28.0	239.9	48.0	42.8	450	53.3	5.9
714	78.0	74.0			81.0	63.0				296.0	74.0	76.0	360	82.2	9.1
742	64.2	61.5			84.0	77.3				287.0	71.8	70.8	360	79.7	8.9
1001	44.3	41.5				48.8	39.3			173.8	43.5	42.9	360	48.3	5.4
1002	48.5	40.0	38.7		35.5	56.0		37.0		255.7	42.6	39.3	540	47.3	5.3
1003	40.0	44.5			45.0				34.5	164.0	41.0	42.3	360	45.6	5.1
1305						55.0				55.0	55.0	55.0	90	61.1	6.8
1398	45.3	39.0			14.5	63.2	49.8	40.3		252.0	42.0	42.8	540	46.7	5.2
1712	66.5	69.0				68.5			64.5	268.5	67.1	67.5	360	74.6	8.3
1742			69.0							69.0	69.0	69.0	90	76.7	8.5
1992	80.0	78.5		69.3	64.0				33.3	325.1	65.0	69.3	450	72.2	8.0
2089	43.3	34.0	39.3		44.8	44.2	35.7	46.5	39.5	327.3	40.9	41.4	720	45.5	5.1
2342					46.0					46.0	46.0	46.0	90	51.1	5.7
2405	63.3	73.5				50.5			29.0	216.3	54.1	56.9	360	60.1	6.7
2463	52.8	53.5	50.2			65.7	58.0	45.7	55.0	380.8	54.4	53.5	630	60.4	6.7
2667							61.0	40.0		101.0	50.5	50.5	180	56.1	6.2
2744	61.3									61.3	61.3	61.3	90	68.1	7.6
3389		59.5				51.3				110.8	55.4	55.4	180	61.5	6.8
3684	51.4	56.0			45.5		44.5	54.0	57.0	308.4	51.4	52.7	540	57.1	6.3
3761	53.0	70.0			56.3		40.5		23.0	242.8	48.6	53.0	450	53.9	6.0
3931	52.7	58.7	54.2	50.4	55.0	64.3			64.0	399.2	57.0	55.0	630	63.4	7.0
4111	39.0	49.5	34.0			32.3	32.3	32.0	18.0	237.1	33.9	32.3	630	37.6	4.2
4169		42.2	23.5			66.0	70.0	38.5		240.2	48.0	42.2	450	53.4	5.9
4310	46.3		49.8							96.1	48.1	48.1	180	53.4	5.9
Subject	Nov-	Nov-	Nov-	Nov-		Nov-	Nov-	Nov-	Nov-	Total	Mean score	Median score	Maximum	% of maximum	% of



	06	07	08	09	Nov-10	14	15	16	17	Score	based on participation	based on participation	possible score based on participation	score based on participation	maximum score
4318		45.8		41.8		51.0	45.0	61.5	47.0	292.1	48.7	46.4	540	54.1	6.0
4478	63.5	63.3	60.0		64.5		63.5	60.0	56.0	430.8	61.5	63.3	630	68.4	7.6
4670	51.8	52.0			64.3	35.4	31.8			235.2	47.0	51.8	450	52.3	5.8
4790	47.0									47.0	47.0	47.0	90	52.2	5.8
4839	22.5	47.0	40.0		72.0	43.0			42.0	266.5	44.4	42.5	540	49.4	5.5
4860	76.3	86.5			35.0				73.0	270.8	67.7	74.7	360	75.2	8.4
4860					74.3		65.0			139.3	69.6	69.6	180	77.4	8.6
4970		55.3	53.0		47.3	73.0				228.7	57.2	54.2	360	63.5	7.1
5109					77.0		57.0			134.0	67.0	67.0	180	74.4	8.3
5366	75.5	78.0	80.3		87.5	83.6	64.3		36.5	505.7	72.2	78.0	630	80.3	8.9
6256		53.0	32.3							85.3	42.6	42.6	180	47.4	5.3
6592					49.7	41.0			56.5	147.2	49.1	49.7	270	54.5	6.1
6744	47.0	42.7	49.5	39.5	59.8	28.7			52.5	319.6	45.7	47.0	630	50.7	5.6
6776					37.0		42.0			79.0	39.5	39.5	180	43.9	4.9
7344		54.7				51.7			34.0	140.3	46.8	51.7	270	52.0	5.8
8187	57.5									57.5	57.5	57.5	90	63.9	7.1
8256	36.8	41.5				43.5	37.2		39.0	198.0	39.6	39.0	450	44.0	4.9
8550	80.5	82.0			89.0		90.0		87.5	429.0	85.8	87.5	450	95.3	10.6
8731	53.5	54.4					35.0	28.0	52.0	222.9	44.6	52.0	450	49.5	5.5
8774	51.2	74.0	38.8		45.9	45.0				254.9	51.0	45.9	450	56.6	6.3
8787			73.0		71.5	65.0			48.5	258.0	64.5	68.3	360	71.7	8.0
8831	62.3	52.0		58.2	62.0	66.8	48.0		57.0	406.2	58.0	58.2	630	64.5	7.2
8872	66.7	66.0		64.4	68.0	68.5			51.0	384.6	64.1	66.3	540	71.2	7.9
9477	74.8	68.0	71.2		74.0				79.5	367.5	73.5	74.0	450	81.7	9.1
9592	57.5	79.0				75.6	60.3	70.7	81.0	424.1	70.7	73.1	540	78.5	8.7
9838	52.0	45.5	38.3	56.0		57.3	38.5	33.3		320.8	45.8	45.5	630	50.9	5.7
9902	57.3	72.0	38.7		63.0	64.0	72.0		54.0	420.9	60.1	63.0	630	66.8	7.4
mean	55.2	57.8	49.1	52.2	57.4	56.5	51.3	46.5	49.3	233.2	53.8	54.4	389.5	59.8	6.6
median	52.8	55.0	49.5	53.2	58.0	56.6	48.9	43.0	51.5	240.2	50.5	52.0	450.0	56.1	6.2

Maximum diagnostic score per day is **90**, and for the nine days of the study is **810** (% of maximum score shown).

Table 6: Summary of mood parameters by subject (continued on next page).

Subject	Nov-06	Nov-07	Nov-08	Nov-09	Nov-10	Nov-14	Nov-15	Nov-16	Nov-17	Total Score	Mean score based on participation	Median score based on participation	Maximum possible score based on participation	% of maximum score based on participation	% of maximum score
89				49.5						49.5	49.5	49.5	130	38.1	4.2
90	34.3	17.7								52.0	26.0	26.0	260	20.0	2.2
176	63.6	56.6			41.5	56.7	63.0	74.0	61.0	416.3	59.5	61.0	910	45.8	5.1
235	74.1	62.0			59.8				51.5	247.3	61.8	60.9	520	47.6	5.3
650	57.8	84.6			44.5	82.0			46.0	314.9	63.0	57.8	650	48.4	5.4
714	84.7	84.0			91.0	73.0				332.7	83.2	84.3	520	64.0	7.1
742	74.7	73.5			97.0	88.7				333.9	83.5	81.7	520	64.2	7.1
1001	54.8	52.0				59.8	54.3			220.8	55.2	54.5	520	42.5	4.7
1002	60.5	50.8	51.3		47.5	66.0		50.0		326.1	54.3	51.0	780	41.8	4.6
1003	52.0	57.5			45.0				46.0	200.5	50.1	49.0	520	38.6	4.3
1305						65.0				65.0	65.0	65.0	130	50.0	5.6
1398	51.9	50.0			24.5	73.2	59.8	50.3		309.7	51.6	51.1	780	39.7	4.4
1712	78.5	80.8				79.5			75.5	314.3	78.6	79.0	520	60.4	6.7
1742			81.3							81.3	81.3	81.3	130	62.6	7.0
1992	94.5	90.0		82.0	64.0				44.3	374.8	75.0	82.0	650	57.7	6.4
2089	58.7	47.3	52.0		54.8	55.4	47.3	54.8	55.5	425.8	53.2	54.8	1040	40.9	4.5
2342					57.0					57.0	57.0	57.0	130	43.8	4.9
2405	74.3	91.2				67.5			45.0	278.0	69.5	70.9	520	53.5	5.9
2463	65.3	63.9	60.2			76.7	69.3	57.7	65.0	458.0	65.4	65.0	910	50.3	5.6
2667							71.0			71.0	71.0	71.0	130	54.6	6.1
2744	61.3	16.7								78.0	39.0	39.0	260	30.0	3.3
3389	10.0	59.5				61.3				130.8	43.6	59.5	390	33.5	3.7
3684	62.9	69.6			55.5		55.5	65.0	67.5	376.0	62.7	64.0	780	48.2	5.4
3761	75.0	84.0			56.3	21.0	57.5		37.5	331.3	55.2	56.9	780	42.5	4.7
3931	63.7	71.7	65.4	62.0	68.0	74.6			75.5	480.8	68.7	68.0	910	52.8	5.9
4111	52.0	62.3	45.0			46.7	49.5	47.0	33.7	336.1	48.0	47.0	910	36.9	4.1
4169	11.6	42.2	35.8			76.0	80.0	51.0		296.6	49.4	46.6	780	38.0	4.2
4310	46.3		62.3							108.6	54.3	54.3	260	41.8	4.6

Subject	Nov-06	Nov-07	Nov-08	Nov-09	Nov-10	Nov-14	Nov-15	Nov-16	Nov-17	Total Score	Mean score based on participation	Median score based on participation	Maximum possible score based on participation	% of maximum score based on participation	% of maximum score
4318	13.2	60.1		56.3		65.7	59.5	74.3	61.0	390.1	55.7	60.1	910	42.9	4.8
4478	75.5	77.3	75.5		64.5		74.5	73.0	71.0	511.3	73.0	74.5	910	56.2	6.2
4670	65.5	63.8			74.3	53.9	45.8			303.2	60.6	63.8	650	46.7	5.2
4790	47.0	20.0								67.0	33.5	33.5	260	25.8	2.9
4839	22.5	47.0	40.0		85.0	43.0			57.0	294.5	49.1	45.0	780	37.8	4.2
4860	88.8	100.3	14.0		54.0	15.3			85.5	358.0	59.7	69.8	780	45.9	5.1
4860	10.0	15.7			87.3	10.0	78.3			201.3	40.3	15.7	650	31.0	3.4
4970	12.3	55.3	66.0		59.3	83.0				276.0	55.2	59.3	650	42.5	4.7
5109					87.0		67.0			154.0	77.0	77.0	260	59.2	6.6
5366	85.5	88.0	90.3		87.5	93.6	74.3		46.5	565.7	80.8	87.5	910	62.2	6.9
6256	0.0	53.0	44.8							97.8	32.6	44.8	260	37.6	2.8
6592	16.0				65.7	55.0			72.5	209.2	52.3	60.3	520	40.2	4.5
6744	57.7	53.9	60.0	50.7	70.8	46.0			66.0	405.0	57.9	57.7	910	44.5	4.9
6776					51.0		56.0			107.0	53.5	53.5	260	41.2	4.6
7344	12.0	54.7				63.3			47.5	177.5	44.4	51.1	520	34.1	3.8
8187	57.5	13.3								70.8	35.4	35.4	260	27.2	3.0
8256	47.8	52.5				56.0	49.0		49.0	254.3	50.9	49.0	650	39.1	4.3
8550	92.5	92.3			101.0		100.0		97.5	483.3	96.7	97.5	650	74.3	8.3
8731	53.5	66.9				17.0	50.5	44.0	67.0	298.9	49.8	52.0	780	38.3	4.3
8774	62.8	84.3	51.8		55.9	55.0				309.8	62.0	55.9	650	47.7	5.3
8787	10.0		83.0		81.5	75.0			62.0	311.5	62.3	75.0	650	47.9	5.3
8831	74.6	62.8		69.2	62.0	77.5	59.3		68.0	473.4	67.6	68.0	910	52.0	5.8
8872	77.2	76.0		74.4	78.0	78.5			61.0	445.1	74.2	76.6	780	57.1	6.3
9477	87.8	79.6	84.8		87.0				91.5	430.7	86.1	87.0	650	66.3	7.4
9592	68.0	92.2				87.2	71.0	80.7	91.0	490.0	81.7	83.9	780	62.8	7.0
9838	64.0	57.8	57.5	66.0		68.0	48.5	42.1		403.9	57.7	57.8	910	44.4	4.9
9902	75.3	88.5	65.7		77.0	76.0	82.0		68.5	532.9	76.1	76.0	910	58.6	6.5
mean	55.0	62.7	59.3	63.8	66.7	62.3	63.5	58.8	62.2	285.3	60.0	61.0	602.7	46.4	5.1
median	60.9	62.3	60.1	64.0	64.3	65.8	59.6	54.8	61.5	309.7	57.9	59.5	650.0	44.5	4.9

Maximum diagnostic score per day is **130**, and for the nine days of the study is **1170** (% of maximum score shown).

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## List of symbols/abbreviations/acronyms/initialisms

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ADVANCE	Advanced Vehicle Architecture for a Net-Enabled Combat Environment
TDP	Technology Demonstrator Project
C2V	Command and Control Vehicle
CF	Canadian Forces
CFB	Canadian Forces Base
DAVPM	Director Armoured Vehicles Program Management
DP	Disposal Point
DS	Directing Staff
LAV	Light Armoured Vehicle
MMEV	Multi-Mission Effects Vehicles

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4. AUTHORS (last name, followed by initials – ranks, titles, etc. not to be used)  <b>Cheung, B.; Nakashima, A.; Hofer, K.; Coyle, 2Lt Brian</b>		
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In the Advanced Vehicle Architecture for a Net-Enabled Combat Environment Technology Demonstrator Project (ADVANCE TDP), there is a need to define the requirements of the active suspension system and how the resulting motion affects performance and well-being (i.e. incidence and severity of motion sickness). At the request of the Director Armoured Vehicles Program Management (DAVPM), a study to investigate the effects of motion disturbance in the LAV III (light armoured vehicle) was completed. During a two-week mechanized platoon commander course held at Canadian Forces Base (CFB) Gagetown, an anonymous questionnaire concerning the rating of 1) motion sickness symptoms and 2) mood and alertness was distributed daily to all of the course participants. Although the participants were encouraged to complete the questionnaire several times each day, compliance with instructions was adversely affected by the operational and physical demands of the course. In addition, uncontrolled variables such as noise, vibration, adverse weather, stress and fatigue likely affected the scores of diagnostic motion sickness symptoms and mood. The most frequently reported motion sickness symptoms were drowsiness, feeling warm and headaches. The most frequently reported mood parameters were weariness, sleepiness, and physical discomfort. Anecdotal reports suggested that the course participants, who were experienced infantry members, had habituated to the motion of the LAV III and were thus less susceptible to motion disturbance than less experienced members.

Dans le cadre du projet d'architecture de véhicule avancée pour environnement de combat réseau-centrique (ADVANCE TDP), il est nécessaire de définir les besoins de la suspension adaptative et la façon dont les mouvements qui en résultent influent sur le rendement et le bien-être (c.-à-d., l'incidence et la gravité du mal des transports). À la demande du Directeur – Gestion de projet de véhicule blindé (D Gest PVM), une étude ayant pour objet d'étudier les effets du mal des transports à bord du VBL III (véhicule blindé léger) a été menée. Lors d'un cours de commandement de peloton mécanisé de deux semaines tenu à la Base des Forces canadiennes (BFC) Gagetown, un questionnaire anonyme où l'on demandait aux participants au cours d'évaluer 1) leurs symptômes du mal des transports et 2) leur humeur et leur vivacité d'esprit a été distribué quotidiennement. Bien que l'on encourageait les participants à remplir le questionnaire plusieurs fois par jour, les exigences opérationnelles et physiques du cours nuisaient à leur capacité de se conformer aux instructions. De plus, des variables non contrôlées telles que le bruit, les vibrations, le mauvais temps, le stress et la fatigue ont probablement eu une incidence sur l'évaluation des symptômes du mal des transports et de l'humeur. Les symptômes du mal des transports les plus souvent signalés furent la somnolence, la sensation de chaleur et les maux de tête. Les paramètres d'humeur les plus souvent signalés furent la lassitude, la somnolence et l'inconfort physique. Des rapports isolés laissent entendre que les participants au cours qui étaient des fantassins chevronnés étaient habitués au mouvement du VBL III et étaient donc moins susceptibles d'être perturbés que les soldats d'infanterie moins chevronnés.

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motion sickness, LAV III, command and control





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